Chapter Seven

SIGHT DISTANCE

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7-1.0 STOPPING SIGHT DISTANCE

Stopping sight distance (SSD) is the sum of the distance traveled during a driver's perception/reaction (or brake reaction) time and the distance traveled while decelerating to a stop. Figure 7-1A presents the SSD values used in design. The designer is referred to AASHTO *A Policy on Geometric Design of Highways and Streets* for the criteria and assumptions used to develop the SSD. The designer should also consider the following:

1. Height of Eye. When applying the SSD values, the height of eye is assumed to be 3.5 ft.

2. Height of Object. The height of object is assumed to be 2 ft.

3. Rounding. The SSD values, as determined from the AASHTO equations, have been rounded up to the next highest 5-ft increment. A design exception is not required if the SSD meets the computed value, and, if due to rounding, does not achieve the value in Figure 7-1A.

4. Grade Adjustments. Because of gravitational forces, downgrades require greater distances for braking and upgrades require lesser distances. Figure 7-1A provides adjusted SSD values for grades. Selection of the appropriate gradient and SSD will be based on the longitudinal gradient at the site of the brake application. Note that, for design exception purposes, only those values that do not meet or exceed the "Level" SSD criteria will require a design exception as discussed in Section 6-6.0.

Design Speed (mph)	Downgrades			Level	Upgrades		
	-9% (ft)	-6% (ft)	-3% (ft)	0% (ft)	+3% (ft)	+6% (ft)	+9% (ft)
20	130	120	120	115	110	110	105
25	175	165	160	155	150	145	140
30	230	215	205	200	200	185	180
35	290	275	260	250	240	230	225
40	355	335	315	305	290	280	270
45	430	400	380	360	345	335	320
50	510	475	450	425	405	390	375
55	595	555	520	495	470	450	435
60	690	640	600	570	540	515	495
65	790	730	685	645	615	585	565
70	895	825	775	730	690	660	635

Notes:

1. *For grades intermediate between columns, use a straight-line interpolation to calculate SSD. For example:*

   V = 55 mph
   G = -4.3%

   $$SSD = 520 + \left(\frac{4.3-3}{6-3}\right)(555-520)$$

   = 520 + 15.2
   = 535.2 ft

2. *See Section 9-3.0 for application of SSD to crest and sag vertical curves.*

STOPPING SIGHT DISTANCE

Figure 7-1A

7-2.0 DECISION SIGHT DISTANCE

7-2.01 Application

At some sites, drivers may be required to make decisions where the highway environment is difficult to perceive or where unexpected maneuvers are required. These are areas of concentrated demand where the roadway elements, traffic volumes and traffic control devices may all compete for the driver's attention. This relatively complex environment may increase the required driver perception/reaction time beyond that provided by the SSD values (2.5 seconds) and, in some locations, the desired vehicular maneuver may be a speed/path/direction change rather than a stop. At these locations, the designer should consider providing decision sight distance to provide an additional margin of safety. Decision sight distance reaction times range from 3 to 10 seconds depending on the location and expected maneuver. The various avoidance maneuvers assumed in the development of Figure 7-2A are:

1. Avoidance Maneuver A: Stop on rural road.

2. Avoidance Maneuver B: Stop on urban road.

3. Avoidance Maneuver C: Speed/path/direction change on rural road.

4. Avoidance Maneuver D: Speed/path/direction change on suburban road.

5. Avoidance Maneuver E: Speed/path/direction change on urban road.

Design Speed (mph)	Decision Sight Distance for Avoidance Maneuver (ft)				
	A	B	C	D	E
30	220	490	450	535	620
35	275	590	525	625	720
40	330	690	600	715	825
45	395	800	675	800	930
50	465	910	750	890	1030
55	535	1030	865	980	1135
60	610	1150	990	1125	1280
65	695	1275	1050	1220	1365
70	780	1410	1105	1275	1445

DECISION SIGHT DISTANCE

Figure 7-2A

In general, the designer should consider using decision sight distance at any relatively complex location where the driver perception/reaction time may exceed 2.5 seconds. Example locations where decision sight distance may be appropriate include:

1. freeway exit/entrance gores;
2. freeway lane drops;
3. left-side entrances or exits;
4. at-grade intersections near a horizontal curve;
5. railroad/highway grade crossings;
6. approaches to detours and lane closures;
7. along high-speed, high-volume urban arterials with considerable roadside friction; or
8. traffic signals on high-speed rural highways.

As with SSD, the driver height of eye is 3.5 ft and the height of object is typically 2 ft. However, candidate sites for decision sight distance may also be candidate sites for assuming that the "object" is the pavement surface (e.g., freeway exit gores). Therefore, the designer may assume a 0.0-in height of object for application at some sites.

7-2.02 Examples

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Example 7-2.1

Given:

An exit on a suburban freeway under design (design speed = 60 mph) is located just beyond a bridge. The freeway passes over. The grade on each side of the overpass is 3%. The freeway will carry high traffic volumes.

Problem:

Determine the needed sight distance to the exit gore.

Solution:

A freeway exit is a major decision point for the driver, and the highway design should provide decision sight distance to the exit gore. The avoidance maneuver is a speed/path/direction change (i.e., Avoidance Maneuver D).

1. From Figure 7-2A, the decision sight distance = 1125 ft.

2. Calculate the length of the crest vertical curve for the freeway overpass. The algebraic difference in grade change is 6%. A height of object of 0.0 in to the exit gore will be used. Section 9-3.0 provides the following equations for vertical curve lengths:

$$L = \frac{AS^2}{200\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}$$

$$L = \frac{(6)(1125)^2}{200\left(\sqrt{3.5} + \sqrt{0.0}\right)^2}$$

$$L = 10{,}848 \text{ ft}$$

3. The calculated length of vertical curve is obviously unrealistic for normal design. Therefore, to meet the decision sight distance value, the designer should attempt to flatten the upgrade and downgrade of the crest vertical curve.

Example 7-2.2

Given:

An at-grade intersection is located just beyond a horizontal curve on an urban 2-lane highway. Both the highway and the intersection carry heavy traffic volumes. Frequent driveway entrances exist on the highway. The design speed is 45 mph. The intersection has experienced a disproportionate number of rear-end crashes on the mainline. The existing conditions are:

R = 1500 ft

Middle ordinate = 33 ft

Available Sight Distance = 500 ft

Problem:

Determine the need for any sight distance improvements.

Solution:

The combination of a horizontal curve, an intersection, high traffic volumes and frequent driveways presents a relatively complex situation for the driver. The high crash rate at the intersection indicates that the existing sight distance around the horizontal curve may be inadequate. This is true even though the existing sight distance exceeds the criteria for stopping sight distance at 45 mph. Therefore, improvements should be considered to provide decision sight distance for a stop condition (i.e., Avoidance Maneuver B):

1. From Figure 7-2A, the decision sight distance = 800 ft.

2. Calculate the middle ordinate needed for the horizontal curve (see Chapter Eight):

$$M = R\left(1 - \cos\frac{28.65S}{R}\right)$$

$$M = 1500\left(1 - \cos\frac{(28.65)(800)}{1500}\right)$$

$$M = 53 \text{ ft}$$

3. Therefore, the roadside obstructions along the horizontal curve should be cleared approximately an additional 20 ft to provide the extra sight distance. If this is impractical, warning signs should be provided to give the driver advance warning of the situation consistent with the values for decision sight distance.

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7-3.0 INTERSECTION SIGHT DISTANCE

Section 11-2.0 discusses the design requirements of sight distance for intersections at-grade.

7-4.0 REFERENCES

1. *A Policy on Geometric Design of Highways and Streets*, AASHTO, 2001.